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FOREWORD

The editors present this number of the *Journal of Geography* in the hope that it may afford some assistance to those of our readers who travel in the West during the coming summer, or other summers. The Western Cordilleras are a veritable wonderland of scenery. The slogan "See America First" is so reasonable that it is sure to have an effect in inducing Americans to see their own country. Perhaps the other slogan "See America too" is still better, if carried out.

In the National Parks, all charges are regulated by government schedules. The railroads issue many booklets treating of the scenery along their lines. Of course these are intended to induce travel and are likely to picture things in the most favorable light. Making allowance for this quality in the advertising material, prospective travelers will do well to obtain and consult these booklets.

RAILROAD RATES TO SALT LAKE CITY FOR THE N. E. A.

From Chicago to Salt Lake City and return, $43.00; from St. Louis, $38.00. From Chicago to Yellowstone Park and return, $44.50; from St. Louis, $39.50. Round trip from Chicago to California, $65.00; from St. Louis, $62.50. From points in the Central Association, two cents a mile each way will be added to the price of the ticket from Chicago or St. Louis. East of Detroit, in Canada, and east of Buffalo and Pittsburgh, they will add one and a half fare.

Every teacher who goes from the east to the N. E. A. at Salt Lake City should aim to see a goodly section of the Rocky Mountain area. The superb scenery of Colorado may be seen to advantage by planning the going and returning routes in advance. The Grand Canyon—in many ways the unrivalled scenic feature of the country—is not far out of the way. The Yellowstone National Park is easily reached. One may visit it in advance of the meeting of the association or on the return. Geography teachers in particular will get an enormous amount of benefit from such a trip.

Secure maps in advance and as you travel, know where you are. The state railway commissions, the state geological surveys and the railways themselves are the sources from which these maps may be obtained. The

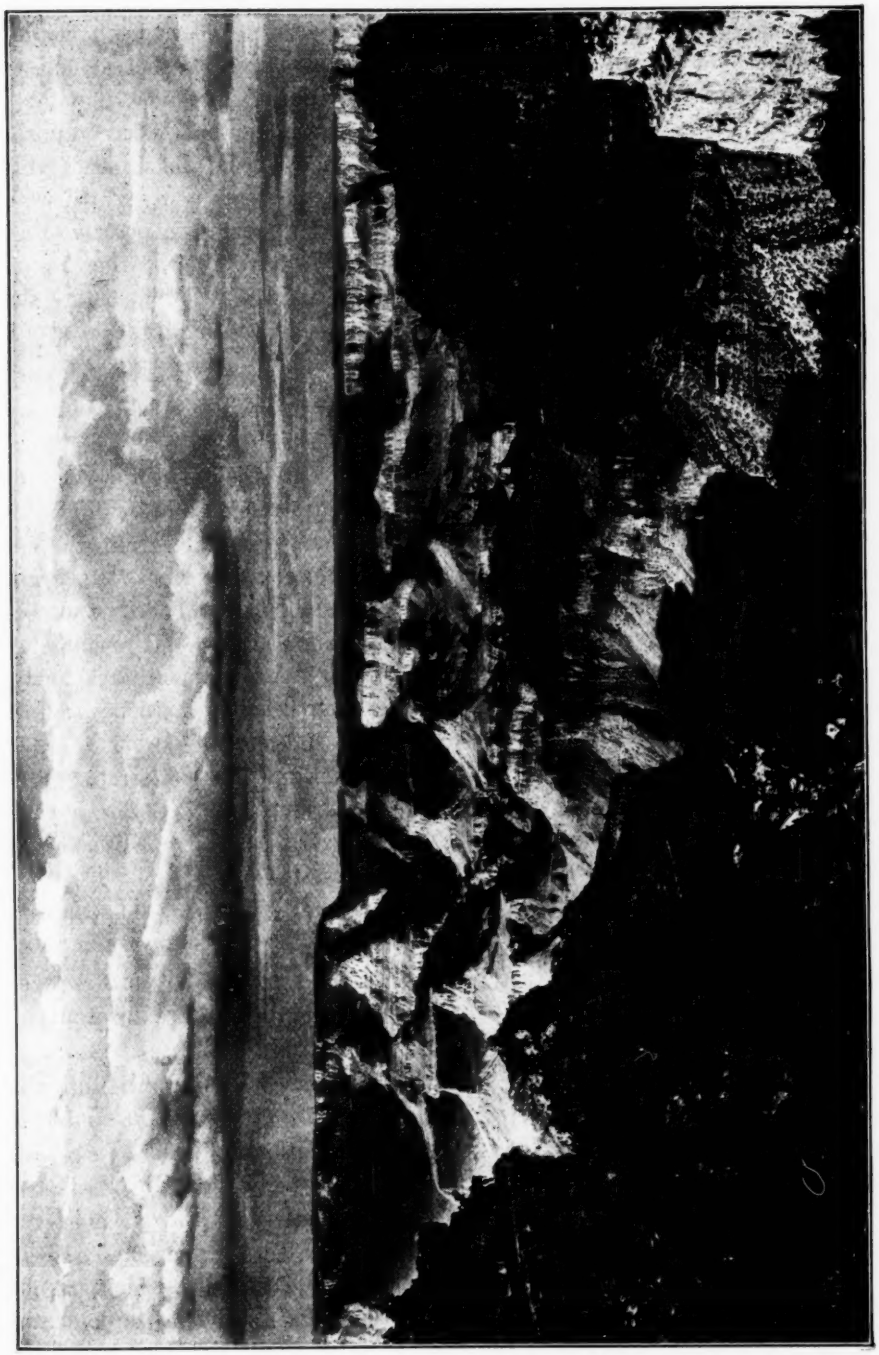
Department of the Interior, Washington, D. C., issues a free pamphlet of information about all of the National Parks. It contains lists of books and magazine articles, and gives detailed information about the scenery, geologic and physiographic features, prices charged by hotels, guides, etc.

THE GRAND CANYON OF THE COLORADO

MOST of the visitors to the Grand Canyon of the Colorado river in the plateaus of northern Arizona look into it in unintelligent wonder. This does not testify to the excellence of our schools, of which we, as Americans, like to think ourselves proud; but it cannot cause surprise to those who realize the utterly insufficient preparation of our teachers of school geography.

The greater number of visitors to the Canyon, failing to conceive the abundant leisure offered during the earth's long history to the patient work of weather and water, still think vaguely about some convulsion of nature which somehow opened a chasm in the plateaus and allowed passage to the river on its way from the mountains to the sea. This vague idea is, like the last scion of an ancient family, to be respected for the antiquity of its origin; but both are obsolescent, and neither has any place in the future.

The canyon, great as its depth may be, is simply a river valley, the work of water and weather like other valleys of erosion. The horizontal strata of which the plateaus are built up are for the most part of marine origin, as the fossils, not rare in certain limestone layers, testify. During and since the relative change of level of land and sea by which plateaus have gained their present altitude of some 8,000 feet, the river has entrenched itself beneath the plateau surface, and the intermittent side streams and the weather have done the rest. All the details of form in the side canyons proclaim them to result from the down-cutting action of streams on their beds and the attack of weather on their walls; the only peculiar feature to note here is that the streams are generally absent; they run only for a time after rain falls, as is the habit of thousands of streams over all the vast arid areas of the continents. A visitor who has the good fortune to be caught in a heavy shower may see how quickly the water runs down the steep slopes, forming a rushing muddy flood in the side canyons; the heaps of boulders in the river at the mouth of each side canyon attest the violent power that such floods occasionally reach. The turbid main river runs and works all the time; its canyon is deep because the plateaus are high. Evidently enough, the side canyons have been cut down no faster than the deepening of the main canyon gave opportunity, as is the rule with the side valleys of main valleys all over the world.



A Scene in the Grand Canyon of the Colorado.

As soon as an attentive observer, walking along the plateau rim and gazing down from one promontory after another into the varied forms of the side canyons, really conceives the simple explanation for the vast chasm by the ordinary processes of erosion and weathering, he must inevitably wonder if the earth is really old enough to have allowed the accomplishment of so enormous a task. When such an observer asks himself this question, he is to be congratulated, for he is on the brink of a great discovery, as well as on the brink of a great canyon. He must soon perceive that the earth is necessarily not merely old enough to have allowed the erosion of the canyon in the plateaus, but old enough to have allowed, before the erosion of the canyon was begun, the formation of the huge pile of strata of which the plateaus are composed.

Look at the vast series of layers in the canyon walls, and strive to conceive the time needed for the accumulation of each successive foot of thickness in their total of thousands. Consider not only the entire thickness of the plateau strata, but also their vast extent; they stretch a hundred of miles north and south of the canyon; their constituent grains came from the destruction of ancient lands elsewhere; their material was transported, grain by grain, from that unknown source, and deposited here. There is no reason for thinking that this three-fold process went on rapidly. It presumably went on at about the same rate as the wearing down of mountains today, as the transportation of detritus by existing rivers, and as the deposition of such detritus on the present sea floor. Hence the ancient periods of time demanded by the accumulation of the vast series of plateau strata, thousands of feet in thickness and thousands of square miles in area, are beyond question vastly long compared to the present period of canyon erosion, as well as antecedent to it.

At first sight, the time needed for the erosion of the canyon seems eternally long; but when it is fairly seen that this eternity must have been preceded by a much longer one, the period of canyon erosion is given its proper rank; it is like a short appendix to a large volume, like a brief afterthought following a long story.

How large is the volume, how long the story? Look down into the depths of the canyon; or better still, walk down the zigzag path and ride out to a point of the gray platform overlooking the deep inner gorge. The gray platform, interrupted by many side canyons is, the surface of a group of sandstone beds, the lowest or basal members in the great series of horizontal strata which constitute the mass of the plateau. The sandstones lie on still older fundamental rocks, which are not horizontal but steeply inclined and greatly deformed. These fundamental rocks were evidently formed before the beginning of the eternity demanded for the deposition of the plateau mass. If patient observation is given to

the decipherment of the history that the fundamental rock record, still earlier eternities must be inferred; thus the perspective of the earth's past history is opened; and in the view of this vast perspective lies the real lesson of the Colorado canyon.

The canyon itself is superb; the revelation of earth history that its walls disclose is overwhelming. The events of that long history include not only successive periods of ancient deposition; but also certain periods of ancient erosion. Consider, for example, the origin of the surface on which the basal sandstones of the plateau strata was laid down. It is a remarkably smooth surface; it is of great extent, for it may be seen far up and down the canyon, and elsewhere; it must underlie the whole extent of the horizontal plateau-making strata. It is evidently a surface of erosion, for it truncates various underlying structures; still more important, it is a surface of completed erosion: that is, it does not exhibit the preliminary forms of deep, steep-sided valleys between high hills, such as characterize the earlier stages of a cycle of erosion, but a broad monotonous expanse, indifferently cutting across all sorts of rocks, such as characterizes the last stage of a cycle, the final accomplishment of erosional work.

Compare this vast buried plain, extending far and wide beneath the plateau strata, with the narrow canyon of the Colorado, and ask which one of these two pieces of erosional work was the greater; which one demanded the longer period of time for its accomplishment. There can be no doubt as to the answer. The erosion of the canyon represents only the preliminary stages of the cycle of erosion now entered upon, the completion of which will require the sweeping away of the whole plateau region, and its reduction to a featureless lowland, little above sea level; while the buried plain, transecting the foundation rocks, represents the ultimate stage of a completed cycle of erosion, which before reaching that stage had had to pass through all the preceding stages. The broad and flat surface of the buried plain represents the end of a great task; the narrow canyon represents only the fair beginning.

How enormously vast is the backward stretch of time revealed in the structure of the canyon walls! As one eternity is recognized before another, the mind becomes so impressed with the total duration represented in their succession, that, if one then considers the canyon again, one may run the danger of regarding its erosion as demanding only a short period of time. Millions of years may well be allotted to it; and therefore scores and hundreds of millions must be allowed to the earlier eternities. Let any inquiring visitor who can, give three days to the canyon: one to strolling along the plateau border, one to descending into the depths of the chasm, and one to a drive eastward through the forest to Grand View point, where the structure of the foundation rocks is best seen and certain problems not

here mentioned are disclosed; and let him give some good part of this time to a deliberate effort to conceive the real lesson that the canyon teaches; not the primary lesson that this canyon, like all others, is the long work of slow erosion, but the more advanced lesson taught by the revelation of the canyon walls, regarding the eternities through which the earth existed before the erosion of the canyon was begun.

There is no place in the world where the great lessons regarding the long duration of geological history are more simply and impressively taught than on the rim of the Grand Canyon of the Colorado. Other deep valleys, as in the Alps and Himalayas, may truly reveal as long a backward perspective through "the corridors of time" to the expert eye, but there the problem is greatly complicated by enormous overturnings of the rocks, difficult to decipher. The walls of the canyon present their majestic succession of formations in extraordinarily simple arrangement, so that a tyro may understand their meaning. Some visitors foolishly spend part of their time, throwing stones from the plateau rim, to see where they will strike the slopes below the cliffs. A better use may be made of the rare privilege of standing in the presence of the awe-inspiring canyon by throwing one's thoughts into its marvellous depths of space and time, to see how far they may penetrate its wonderful meaning.* W. M. DAVIS.

YELLOWSTONE NATIONAL PARK

YELLOWSTONE PARK is not a mountainous country as is often supposed by those who have not seen it. Far from that, it is a plateau, having extensive tracts which are almost level. Here and there are steep slopes where a high tabular surface gives way to a lower one. A few isolated mountains rise above its surface and canyons are cut beneath it. The elevation ranges from 7,200 feet to 8,300 feet, the average height between streams being about 8,000 feet. In any broad outlook, the narrow valleys are overlooked and the country seems almost level. This plateau view, however, terminates on all sides against mountain ranges, some of them as rugged and sublime as any in North America.

Like most of the Rocky Mountains, these ranges surrounding the park plateau were made by upheaval, largely near the close of Cretaceous time. But it is not the rocks upheaved at that time which constitute the present surface. Those rocks were largely covered up and the height of the mountains much increased by vast quantities of volcanic rock, mainly fragmental, but in smaller part lavas. These came from the now extinct volcanoes within the ranges.

***The Grand Canyon is reached by the Atchison, Topeka and Santa Fe Railroad. There are two hotels, the luxurious El Tovar and the comfortable Bright Angel, at the Canyon. Guides, horses and carriages are obtainable. For booklets and other information, write Passenger Dept., A. T. & S. F. Ry., Chicago.**

When all these mountains had been built substantially to their present height, there remained between them in the present site of Yellowstone Park, a deep basin with an uneven floor 1,000 to 2,000 feet below the level of the present park. The last great volcanic event (there were minor eruptions later) was a series of enormous lava flows which filled this basin to its present level. These flows came from two great volcanoes within the park. Although this was the last of the great volcanic events, it was so long ago that these volcanoes have since been changed in form by water and ice erosion and have doubtless lost some of their height. Mt. Washburne in the northeast part, beside the great canyon, is a high point on the rim of one of these volcanoes and Mt. Sheridan in the south-central part, similarly represents the other.

Not only have the mountains been wasting, but streams have begun to cut down into the lava plateau. Yellowstone River, a small stream, has thus cut a canyon 1,000 to 1,500 feet deep; some of its tributaries have canyons more than half as deep. The canyons on the various branches of the Snake on the south, and the Missouri on the west, rival those of the Yellowstone in the north and east, all cut since the great lava flows.

The whole of the glacial period also transpired since the great eruptions which filled the basin and built the plateau. To the ice of this period the mountains owe much of their sculpture. Glaciers occupied many of their valleys, cutting down their bottoms, oversteepening their sides and converting many divides into mere lines of crags. Even in the plateau some valleys were changed in this way by the ice, while others were partly or wholly filled with drift.

The events thus described, volcanic, glacial and fluvial, give the ultimate explanation of all the features which make Yellowstone Park unique and famous. Among these, we may give some attention to the mountain of volcanic glass, the petrified forest, the hot springs and geysers, the fumaroles, the lakes, the falls, and the canyons.

Obsidian Cliff. The lava which filled the basin and built the plateau is of the acid kind which melts only at very high temperatures and therefore hardens quickly after eruption. Some solidified so promptly as to make a black glass. The stage road from Mammoth Hot Springs to the Geyser basins, runs at the foot of a 500-foot cliff of such volcanic glass. It is justly famous and very beautiful but no more mysterious than the slag from our iron furnaces, which often hardens in the same way. At other places the same lava cooled more slowly, making a dense, stony mass or even a crystalline rock.

The Fossil Forest. In the north-eastern part of the park, near Lamar River, is an area containing many fossil trees and other plants of many species. Some of the petrified tree trunks are remarkable by reason of

standing in an upright position to a height of fifteen feet or more. These were buried by fragmental material (breccia), blown from volcanoes long before the filling of the park by lava flows. They were deeply buried and immersed in the ground water which circulated through the breccia. The error is sometimes made, of thinking of these logs as still petrifying. As

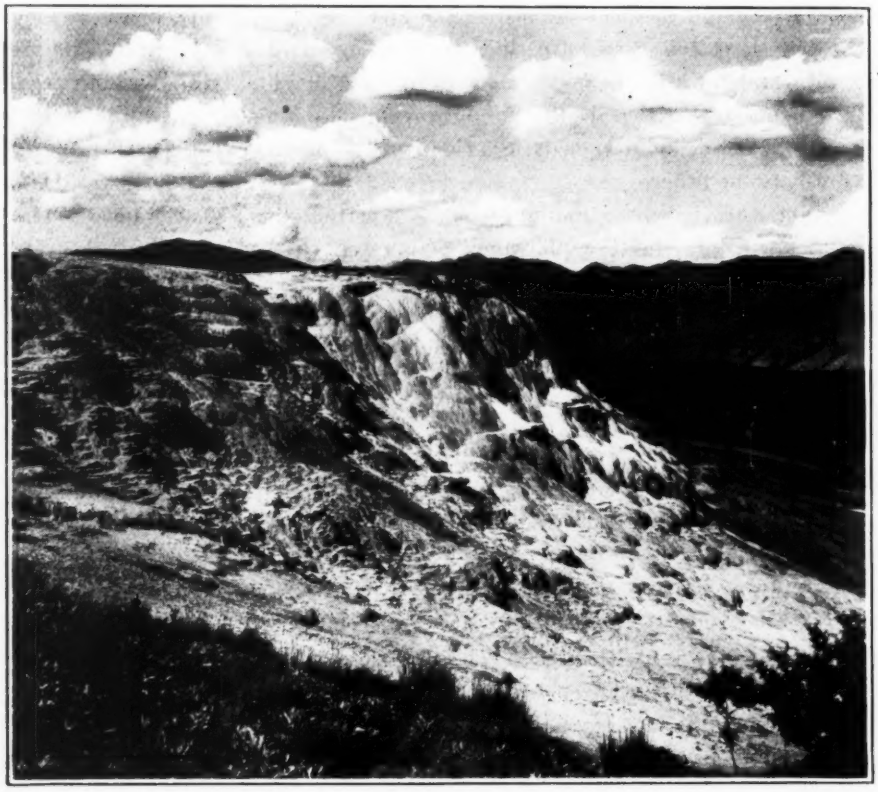


Fig. 1. The Jupiter Terraces, Beautiful Formations Built up by the Hot Springs

soon as the overlying rocks were eroded away and these trees were no longer immersed in ground water, they became subject to decay.

Geysers and Hot Springs. The one thing which, above all others, makes Yellowstone Park a wonderland, is its geysers. A geyser differs from a hot spring only in having occasional or periodic eruptions, during which the water is violently expelled by steam. Both depend, directly or indirectly, on the heat of volcanic rocks, (unless the springs be only warm). This may be either the residual heat of lavas erupted but not yet cooled, or heat of volcanic action not yet dead. In either case, it is seen that the geysers owe their existence to the volcanic nature of the area.

The phenomena of these geysers indicate (1) that geyser water is mere

surface water which has percolated downward to the source of heat, (2) that it does not come into immediate contact with the hot rocks themselves, but is heated by steam which rises from the latter through crevices. The explanation of the eruptive habit (sufficiently given in most good text books) implies that the water which fills the passage down to the source of heat is heated at the bottom to a temperature much higher than would suffice for boiling at the surface. Incidentally it may be said that at the elevation of most of the Yellowstone geysers, water boils at 198 degrees F. instead of at 212 degrees, as at sea level.

To even attempt a description of the various geysers of different size and habit would require many pages and would duplicate the most oft-repeated descriptions. They vary in quantity of water erupted, from a few gallons to thousands of barrels; in height of eruption from several feet to several hundred feet; in period from a half minute to a few weeks or even longer. Some play at regular intervals for many years, others at irregular intervals. Some throw a straight vertical shaft of water (except for the effect of wind), others discharge obliquely or throw out an irregular mass or sheet of water. Some receive back their waters into their own basins to be erupted again, others not. Some have wide open basins with the orifice at the center and lowest part, others spout from the apex of a cone built of siliceous deposits made by the water, other still have irregular mounds.

The deposits around these geysers, (sinter or sometimes geyserite) are chiefly of silica which the hot alkaline waters have dissolved from the volcanic rocks. Some geyser waters contain so much in solution that a part is precipitated on cooling. Others carry less and precipitate it only on evaporation. Algae which use silica are perhaps the chief agents in making these deposits. They inhabit most of the hot waters. Different species have different colors and are adapted to different temperatures up to 185 degrees F. There is therefore an element of truth in the assertion that the temperature of the water may be known by the colors of the sinter composing the bowl. Normally, when pure, this substance is white or pearly. The algae living on its surface impart the rich soft colors, flesh red, salmon, orange, various shades of brown and green.

Most of the Yellowstone geysers are found in three basins or flats along the Gibbon and Firehole rivers (headwaters of the Madison) in the western quarter of the park. All are in valleys where springs might normally be expected.

Hot springs are well distributed over the park, but the Mammoth Hot Springs on Gardiner River in the northeast corner belong in a class by themselves both for size and beauty. Vast quantities of steaming water issue from numerous vents on hillsides descending from basin to basin arranged like giant stairs, the tread in each case being a pool of hot water;

the rise being made by a rim of travertine precipitated from the water. (Fig 1.) Unlike the geyser waters, these carry lime in solution instead of silica. The resulting deposit of travertine covers several square miles and suggests the vastness of hot spring activities in the past.

Fumaroles are vents from which steam and other vapors issue. In some cases such vapors are acid. These, along with the heat and the moisture, strongly affect the rocks through which they pass and have at places decomposed the solid lava over thousands of acres and for hundreds of feet

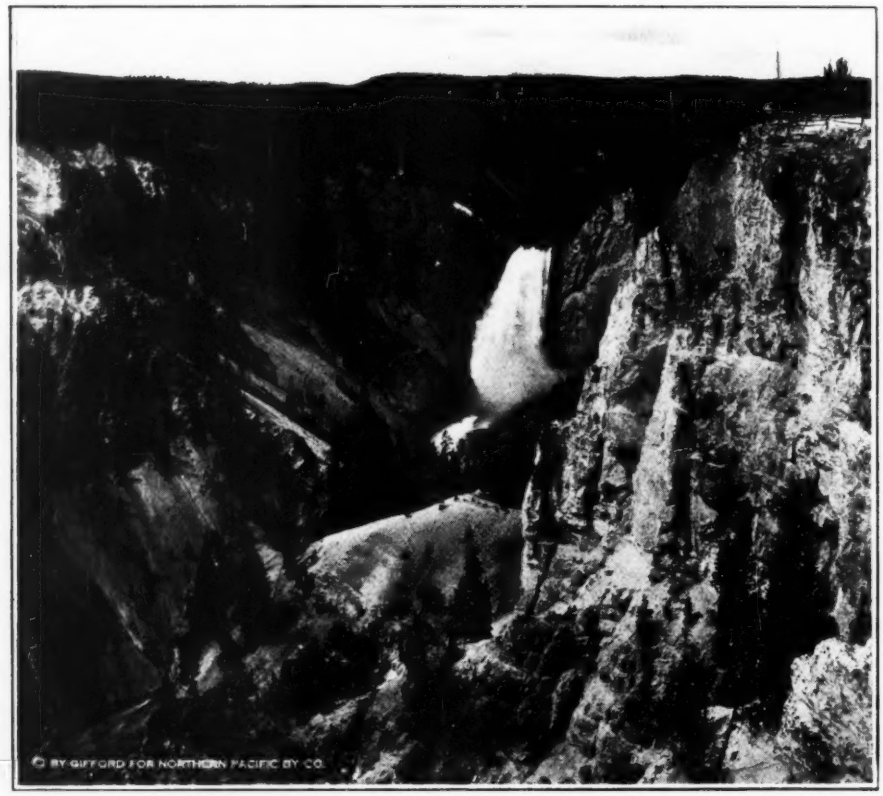


Fig. 2. The Canyon and Falls of the Yellowstone

in depth. This is best seen at the great canyon of Yellowstone River where the walls of the gorge are of a chalky whiteness, clouded and streaked with yellow, orange, red, brown and even greenish products of rock decomposition (Fig. 2). The wonderful depth and beauty of the canyon are due in large measure to the ease of downcutting caused by decay which was due in turn to fumaroles. Local masses of fresh rock more successfully resisted the downcutting and caused the famous falls.

Lakes. Were it not for the more unusual phenomena of hot water in the northern part of the park, the lakes of its southern part would be suf-

ficient to give it distinction. Many of them are due to glaciation. The share which lava flows had in making these basins by the damming of earlier valleys has not been determined exactly.

It is certain that Yellowstone Lake had a former outlet near its southern end, to the Snake River, and that its surface was then 160 feet above its present level, and that it then extended north beyond the present Falls of the Yellowstone River. This much is known from fossil shore lines at the former level and from the channel of the old outlet, a narrow, clean-cut trench in the rock, with a flat marshy bottom. Various hypotheses might account for its change of outlet. There is much reason to think that the real cause was the headward growth of a small stream which flowed northeast at the foot of Mt. Washburn. The gulley-like head of this stream could easily have elongated itself toward the southwest, following the line of fumaroles and decomposed rock. Having thus extended itself until the lake was tapped, it is easy to account for the rapid carving of the gorge, the abandonment of the southern outlet, the falling of the lake level and the occurrence of falls where the new stream in its down-cutting came upon reefs of undecomposed rock.

Canyons and Falls. Other streams beside the Yellowstone have canyons, some of them nearly as deep. Most of these streams head within the park and cut their canyons only near its edge as they pass out. Most of them, likewise, have beautiful falls due to unequal hardness of rocks or partial decomposition.

Access to the Park. Before the days of railroads, this was one of the least accessible regions in the Rocky Mountain States. It was not visited by any man who kept a record until 1870, when Surveyor-General Washburne of Montana, went in with a party. He was followed in 1871 by Dr. F. V. Hayden, in charge of the Geological Survey of the Territories. It was in response to Dr. Hayden's earnest plea that the park was created by Congress in 1872. The park is now reached by two railroads. The Northern Pacific sends down a branch from Livingston, Mont., which reaches the park at Gardiner on the northern boundary. The Oregon Short Line between Pocatello, Idaho, and Butte, Mont., sends in a branch to the Western boundary at Yellowstone, Mont. The Burlington on the east side reaches Cody, Wyo., from which a stage drive of 63 miles across the Absaroka Mountains reaches the eastern entrance of the park. Stage lines under government control traverse the park, operating in connection with elaborate hotels under the same control. These stages run on exact schedules to meet the needs of those who wish to see the most in the least time. Traveling by stage and stopping at hotels costs roughly $10.00 per day for the usual 5-day trip. The expense may be considerably reduced by traveling and camping with certain licensed companies. Under proper restrictions, private camping parties are also permitted. Full information concerning priv-

ileges and modes of travel is furnished by the Department of the Interior at Washington, in a circular designed to meet the needs of all visitors. This circular is gladly sent to all inquirers. It contains an excellent bibliography of the Park, including mention of the excellent government maps. Three non-technical publications of the first importance are:

Geological History of the Yellowstone National Park; by Arnold Hague, 24 pp. illustrated—10 cents. Address Supt. of Public Documents, Washington, D. C.

Geysers; by Walter Harvey Weed; 32 pp.—illustrated; 10 cents. Address Supt. of Public Documents, Washington, D. C.

U. S. Geol. Survey folio, No. 30, 50 cents. Address The Director, U. S. Geol. Survey, Washington, D. C.

See also articles in standard cyclopedias, Brittanica, Universal, etc. Address the General Passenger Agent, Northern Pacific Ry., St. Paul, Minn., for illustrated booklets. N. M. FENNEMAN.

THE GRAND COULEE, WASHINGTON

A LITTLE over a one hundred miles west of the thriving city of Spokane, Washington, and extending for more than fifty miles from north to south is a great valley, that ranks among the most striking of the many splendid scenic features of the northwest. It is a valley in form but it contains no river, and the river with which its story is connected lies in a deep vertical-walled trench about five hundred feet below the Grand Coulee. A dry valley does not sound like an appealing bit of scenery, but anyone who will brave the aridity, dust and discomfort of a journey to this great feature will be more than repaid; for there is nothing like it in size, grandeur or impressiveness anywhere else.

The Grand Canyon of the Colorado, magnificent, awe-inspiring, and tremendous beyond description, contains a seemingly insignificant stream that one can see at work. Its story in the large is clear. So is the story of Niagara. But in the Grand Coulee, we have a valley set down below the surrounding country nearly four hundred feet, bordered by vertical walls of volcanic rock, and in its course a fossil waterfall three times as high as Niagara and several times as wide. To the colors and impressiveness of the great extent of the desert, is added the seeming mystery of this story of former river work, the record of which is written in clear and vigorous landscape language that anyone can read but no one can wholly understand.

Anyone who visits the Grand Coulee in the late summer will see more than striking valley scenery that will repay him for his trouble. Riding out into the great lava fields of the Columbian Plateau to the town of Almira*, one can, by arrangement, secure automobiles that will carry him to

A branch of the Northern Pacific R. R. runs northward from Adrian to Coulee City, near the great abandoned cataract. The Grand Coulee may be reached from Spokane either by the Northern Pacific or the Great Northern.

the northern end of the Coulee. The ride itself is full of interest for everywhere are the crops of wheat and oats growing in the fine brown soil that overlies the lava. The soil is like veritable dust, almost without grit, but by the system of tillage, known as *dry farming,* it is made to produce in ordinary years, abundant crops of cereals. The road winds over the gently rolling slopes of the plateau, and one may see occasional farm houses, nestled in slight hollows where water is available. This "arid, barren waste," once the home of wandering cattle, is now the seat of wide-spread agriculture.

Then suddenly the scene changes, the soil cover grows thinner, the solid lava forms the surface, the road grows more rough and then appears the northern end of the Grand Coulee, and below it the narrow gorge of the Columbia River, that can be seen coming from the east and bending to the north until it disappears from view in the higher plateaus.

The Coulee here opening out as a broad, nearly flat-floored valley suggests the work of running water, and it requires no imagination to see that its story in some way is connected with the story of the Columbia. It is obvious that the straightest route for the Columbia is not around the Big Bend but along the Grand Coulee. Yet this has not been followed; the story is involved, by no means clear, and yet there is the great valley high hung in the lava rocks and extending for fifty odd miles to the south.

To follow its course is a trip of a lifetime. Everywhere dust, desert and dry farming; through the northern end and farther south water appears first brackish and again as springs. The wheat fields give way to irrigated fruit orchards, alfalfa fields and gardens, and one finds himself at thriving Coulee City, feeling well rewarded for a hard and long day's work. But the best is yet ahead, for five miles below Coulee City, along the Coulee are the fossil water falls, and rapids, as clear cut as the rapids and falls of Niagara and far more impressive for their size and their silence.

Below the crest of the falls may be seen large lakes formed by the plunging water and called therefore Plunge Lakes; and down stream from the falls the narrow trench formed by the river, just as Niagara has formed its gorge between the falls and Lake Ontario. A map of Washington will show a succession of lakes extending for many miles southward of Coulee City and toward where the Columbia, after its sweep around the Big Bend, turns southward before its last great turn to the west toward the Pacific.

Such in general are the abandoned valley and falls of the Grand Coulee. But a trip through this grand canyon will reveal many details of equal interest,—islands of lava standing in the valley, and granite knobs, drowned once under the great lava flows and now revealed by the work of the stream that once ran through the Grand Coulee and made it. And everywhere are the evidences of man's success in conquering aridity and putting to work the fertile soils that only need perseverance, science, human leadership and vim to make then more than productive.

Physiographically, the Grand Coulee presents a story that is unique; scenically it is one of the little known but most impressive features of our country; geographically, it is a center of human life, human effort and human success, that thrills anyone who is familiar only with life in well watered regions where scenery is on a relatively small scale and agriculture in general is intensive rather than extensive.

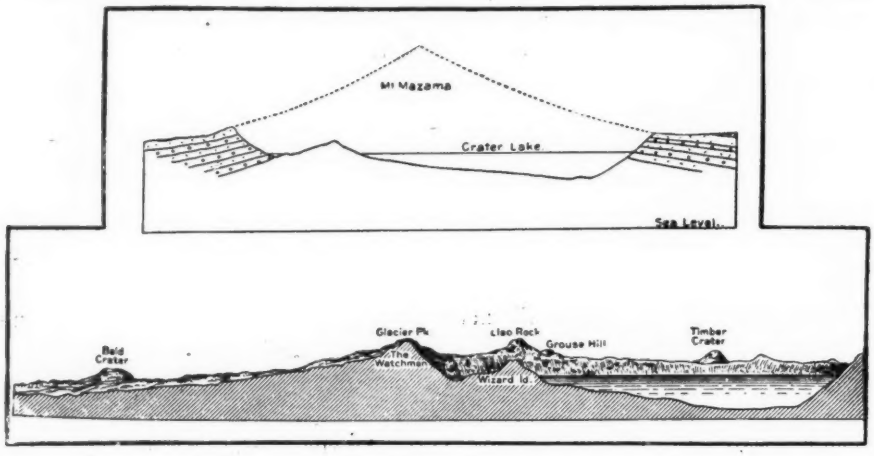
Reference—I. C. Russell, *A Geological Reconnaissance in Central Washington;* U. S. Geological Survey, Bulletin 108.

F. C. Calkins, *Geology and Water Resources of a Portion of East Central Washington;* U. S. Geological Survey, Water Supply Paper 118.

RICHARD ELWOOD DODGE.

MOUNT MAZAMA AND CRATER LAKE

THE line of splendid volcanoes of western United States, from Mt Shasta in California to Mt. Hood in Oregon and Mounts Rainier and Baker in Washington, includes also a volcano which is little known. Its name is Mt. Mazama and the reason for the unfamiliarity of the name is that most people think, not of the mountain, but of the body of water which



Upper figure—Mount Mazama Restored.
Lower figure—Cross section through Crater Lake. (After J. S. Diller).

occupies its top,—Crater Lake. The lake is nearly 2,000 feet deep and its surface is 6,177 feet above sea level. As one of the loftiest and one of the deepest lakes in the world, Crater Lake has a well-deserved popular fame. The mountain, however, is even more interesting than the lake; and as it is now a National Park and as travellers are going to the region every year in increasing numbers it seems desirable to know more about Mount Mazama itself and the history of the mountain which has preceded the formation of the lake basin.

Leaving the railway*, on the main line between Portland and San Francisco, either at Medford or Ashland, or at Klamath Falls, Oregon, you can drive out to Crater Lake by automobile, taking a day to drive each way and spending a day at the crater rim in a comfortable tent hotel, taking a forenoon for a launch trip on the lake. The drive from Medford to Mt. Mazama is a delightful one. You travel 85 miles and in this distance you ascend over a mile. The journey is in four contrasting portions. 1. Near Medford you pass through the apple and other fruit orchards of the Rogue River valley, where man has made the dry land into a veritable garden. 2. You pass into the rugged foothill region with its grazing industry. 3. After this you traverse a long, wooded valley with the road winding through a virgin forest of great sugar pines, Douglas firs, and cedars, where the ground is littered with pine cones a foot to eighteen inches in length. 4. Lastly the road ascends a steep slope, the base of the former volcano, now called Mt. Mazama.

Arriving at the crater rim you look into a vast caldera, occupied by an intensely-blue lake. The lake is 5 miles in diameter. Its walls rise precipitously 500 to 2,200 feet. Within the lake is a small volcanic cone, Wizard Island, which rises 763 feet above lake level and contains a small crater 150 feet deep.

Valleys cut by streams in the slopes of Mt. Mazama and heading in the air at the crater rim show that a lofty peak formerly rose on the site of the present caldera and lake. This conclusion is supported by the presence of glacial striae upon the crater rim. They can have been formed only by ice streams which flowed down from a former lofty mountain. The same thing is also proved by the lava flows, such as that of Llao Rock, which must have descended from the former mountain. The igneous rock of the crater rim and lava streams proves that this former mountain was a volcano. Some of these flows occupy ancient lava-filled valleys which must have headed on a lofty volcanic peak.

Having established the fact of a former lofty cone of Mt. Mazama, the question arises as to what has become of it. Two methods of destruction suggest themselves, (1) explosion or (2) engulfment. Diller, who described most of the features here summarized, concluded that it was engulfment, for the surrounding region is not littered with fragmental material as would be the case if the crest of the volcano had been destroyed by explosion.

Wizard Island, however, is not the tip of the engulfed cone, as was stated recently in a popular periodical whose circulation is 2,000,000 copies a week, and from which many teachers may gain an erroneous idea. If that were the case it would occupy the center of Crater Lake and not its extreme margin. The island is a more recent volcanic cone.

*The Southern Pacific.

The history of Mt. Mazama as an original volcano, fully as high as Mt. Shasta, and with slopes eroded by streams and glaciers, and of its destruction by the sinking down of the cone, is one of fascinating interest compared with the mere fact that there is a deep lake of mysterious origin upon a mountain peak.

REFERENCES *Map of Crater Lake National Park,* The Director, U. S. Geological Survey, Washington, D. C., 10 cents a copy.

Geological History of Crater Lake, by J. S. Diller, 1912, 24 pages, illustrated. Superintendent of Documents, Government Printing Office, Washington, D. C. 10 cents.

Geology and Petrography of Crater Lake National Park, by J. S. Diller and H. B. Patton, 1902, 167 pages, 19 plates, Professional Paper No. 3, U. S. Geol. Survey. 40 cents.

Steel Points, Crater Lake, Vol. 1, No. 2, 1907, by W. G. Steel, Portland, Oregon. 10 cents.

LAWRENCE MARTIN.

GLACIER NATIONAL PARK

AMONG the National Parks recently established in western United States none is more beautiful and interesting than the one in the front range of the Rocky Mountains in northern Montana. The writer bases this statement upon what he saw of the region eight years ago, before the roads, trails, and hotels were established in the region. Here one may see glaciers, as the name of the park suggests, and although they are not as large as those on Mount Rainier, which contains the largest ice streams in the United States, they are in no way inferior to the glaciers along the Canadian Pacific Railway a little farther north. They are smaller than the ice tongues of the Alps and are mere pigmies compared with the glaciers of Alaska, but the Blackfoot Glacier and its neighbors in Glacier National Park are perfectly typical and to Americans they are very accessible. The present glaciers, numbering some scores, are not, however, nearly as interesting as the features of former glaciation in this region.

Leaving the railway* at Glacier Park or Belton or Midvale, after two days' journey from Chicago or Kansas City, you can enter the park by automobile or stage, seeing a little of the Great Plains en route. Or if you start from the western side you have, first, a journey by lake steamer. In the park you travel by wagon or saddle horse or on foot, stopping at chalet hotels or at comfortable camps. You can see something of the park in a day or two, but 9 to 12 days constitute the standard tours.

You may visit the glaciers, but these are mere incidents in a wealth of

*Great Northern Railway.

scenery. The rock structure is that of the Dolomites in the Austrian Alps, with turreted peaks and castellated aretes. An interesting feature is that in

Fig. 1.

the mountain-making the very old rocks have been thrust eastward over the young rocks for a distance of at least 5 to 7 miles. As the old rocks are resistant and the young rocks weak, this results in steep precipices above the gentle slopes below, in the eastern part of the park, as you can see in Chief Mountain and in the Swift-current and Upper St. Mary valleys,

Fig. 2.

especially at the Narrows in Upper St. Mary Lake where the constriction is formed at the point of disappearance of the weak younger strata beneath the resistant older rock.

The glacial features are numerous. They include glacial cirques (Fig. 1), as at Gunsight Lake, Iceberg Lake, and Avalanche Basin. There are hanging valleys, as at the junction of the stream from Gunsight Pass and the one from Blackfoot Glacier. There are alluvial fans of glacial outwash gravels, as where the fan of Swiftcurrent Creek forms a dam for Lower St. Mary Lake and, even better, where the streams of two opposite deltas have cut the St. Mary Lakes in two, just as at Interlaken in the Swiss Alps and at Buttermere and Crummock Water in the English Lake District. There are terminal moraines, as at the end of Duck Lake east of Babb. There are buried hanging valleys as in the case of the junction of Swiftcurrent and St. Mary rivers, where the discordant junction was revealed by borings in the alluvial fan in connection with the proposed Reclamation Service dam at Babb. It is known that there was not only continental glaciation on the Great Plains to the northeast, but that the mountain glaciation has been double, the cemented till deposits of the ridges between Two Medicine, Cutbank, Milk, and St. Mary rivers being of the sort known as older drift.

The mountain scenery is far superior to that in Yellowstone Park, though there are no interesting geysers, hot springs, waterfalls, and great stream-cut canyons. The Glacier Park is a region in which to see the work of the former glaciers, and in this respect there is no finer place in the world.

REFERENCES: *Map of Glacier National Park*, The Director, U. S. Geological Survey, Washington, D. C., 15 cents.

Some Lakes of the Glacier National Park, by M. J. Elrod, Superintendent of Documents, Government Printing Office, Washington, D. C. 29 pages. 10 cents.

LAWRENCE MARTIN.

THE YOSEMITE NATIONAL PARK

LAST year the U. S. Geological Survey published a 47-page booklet on the Yosemite Park, written by Mr. F. E. Matthes*. It includes a score of beautiful half-tone illustrations, several drawings and a map. It is the most satisfactory publication dealing with this very interesting region that we know of. In the following excerpts, detached as they are, injustice is necessarily done Mr. Matthes' excellent description.

GENERAL FEATURES

The general lay and configuration of the tract inclosed by the Yosemite National Park can be best understood by taking a broad, preliminary

*Sold by the Supt. of Documents, Washington, D. C., for 10 cents.

view of the Sierra Nevada as a whole. That range, which is one of the greatest mountain ranges of the western United States, runs lengthwise through the State of California, roughly paralleling the Nevada border. More than 300 miles long and about 80 miles wide, it constitutes a huge rampart separating the desert basins on the east from the Great Valley of California on the west. Rising abruptly from the desert by a steep face or escarpment several thousand feet high, it descends to the low level of the Great Valley by a long and gentle sweep * * * * * * The crest of the Sierra Nevada stands at altitudes ranging from 10,000 to 14,000 feet, culminating in Mount Whitney (14,501 feet), the highest summit in the United States.

Effect of Glaciation

The Yosemite and Hetch Hetchy Valleys, though in many respects resembling the glacial canyons of the High Sierra, nevertheless possess a distinctive, if not exceptional, character that places them in a category by themselves. They may be described as deep-hewn, clean-cut moats bordered by precipitous rock walls that sharply trench across the surface of the uplands and spring abruptly from broad, level, grassy floors. Waterfalls and cascades of great height and beauty leap down into both chasms from the hanging valleys of the upland, and the cliffs themselves are sculptured into a variety of bold and picturesque forms, such as are scarcely known elsewhere.

In length the Yosemite Valley measures about 7 miles; in height its walls range from 3,000 to 4,000 feet; its floor width averages one mile. The Hetch Hetchy Valley, which is essentially similar in its characteristics, is only three miles long, half a mile wide, and some 2,000 feet deep. Both valleys lie at fairly low levels, the elevation of the floor of the Yosemite above the sea being 3,960 feet, that of the Hetch Hetchy Valley 3,660 feet.

Origin of the Valleys

The most probable explanation is that Yosemite and Hetch Hetchy Valleys both, like the other canyons and valleys of the High Sierra, have been developed through stream erosion consequent to the uplift of the Sierra block, and have later been greatly deepened and enlarged by repeated ice invasions; further, that they owe their strangely clean-cut, moat-like forms and the diversified sculpturing of their cliffs to the structure of the country rock, which has locally controlled the action of the eroding agents.

There is every reason to believe that the Yosemite and Hetch Hetchy Valleys are, in the first place, of stream-cut origin. Their relations to the other parts of the Merced and Tuolumne Valley systems leave no room for doubt on this point. That both valleys have been visited by glaciers descending from the Sierra crest is now also settled beyond dispute. No one familiar with the evidences of ice work could be misled in this regard.

The Influence of Rock Structure

The Yosemite Valley is strangely constricted near its middle by two great promontories that advance out into it from opposite sides, while immediately above and below this gateway the valley is wider than anywhere else. The hanging valley of Bridalveil Creek projects like a headland into the main trough, and the Bridalveil Falls itself anomalously leaps from the end of a cape. No less puzzling is the occurrence of the two ponderous granite bosses, Liberty Cap and Mount Broderick, that bar the Little Yosemite at its lower end. The valley walls themselves present an array of rock forms surprising both in size and in sculptural shape. Colossal undivided masses, such as El Capitan, thousands of feet high and broad, contrast with forms of utmost fragility, such as the fingerlike minarets of the Cathedral Spires. Huge blank walls of mural straightness, as those under Glacier Point or the Yosemite Falls, alternate with sharp-cut re-entrants and overhanging recessed arches, while upward the rock masses terminate for the most part in bare, rounded, helmet-like forms, such as North Dome and Sentinel Dome. Finally, at the head of the Yosemite Valley, dominating the entire landscape, stands that most enigmatic of all rock monuments of the High Sierra, the famous Half Dome. * * * * *

The Yosemite Valley evidently was carved from prevailingly fissured materials in which the ice was able to quarry to great depth and width. * * * * But it did not erode with equal facility at every point; some of the rock materials were more readily quarried away than others, and various inequalities in the trough form have resulted.

The Domes. Not all the Yosemite cliffs, however, are of the rectilinear, clean-cut sort; a surprisingly large number are laid out on rounding curves. The dome-shaped eminences bordering the valley evidently belong to the same category of rock forms. Placed apparently at random in the landscape, these huge, bulging masses of bare granite give it in no small degree its unusual character. * * * * *

The real origin of this peculiar structure is not yet fully understood, but this much can be said with certainty, that it develops only at the surface and must be due to expansive stresses in the rock which have come into play since the domes were uncovered by denudation and became exposed to the weather.

The remarkable roundness of the Sierra domes has by some been attributed to ice erosion, but this view is clearly based on a misconception. However much of the peculiar rock topography of the Sierra landscape the ice may have sculptured, it did not carve the domes.*

***The Department of the Interior, Washington, D. C., issues booklets giving full information for tourists who contemplate visiting any of the National Parks; these are sent free on application to the Secretary of the Interior.**

THE PETRIFIED FORESTS OF ARIZONA

PETRIFIED wood is found in many places in the state of Arizona, New Mexico, and Utah; but the National Monument known as the "Petrified Forest of Arizona" lies near the eastern boundary of the state, just south of the Painted Desert, and between the Rio Puerco and Zuni River, both of which are tributaries of the Little Colorado. These forests are often classed among the strange features of our country and are in fact somewhat off the beaten path of the ordinary tourist, though quite accessible. A visit to this region is well worth while, as the petrified forests near Adamana probably exceed in beauty, in brilliancy and variety of coloring, and in extent all other similar deposits in the world. The western edge of the region is about fifteen miles east of Holbrook, and the northern border of forest No. 1 is six miles south of Adamana (Fig. 1).

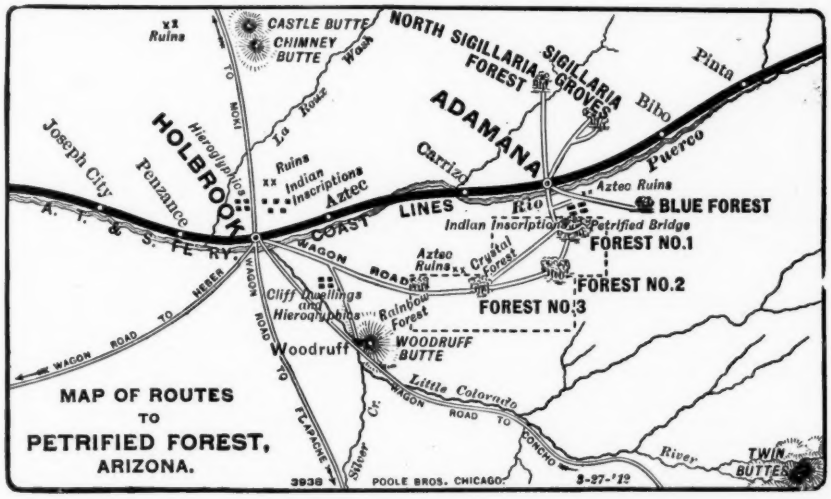


Fig. 1.

The forest covers many thousands of acres, in five separate tracts, all easily reached from Adamana, on the Atchison, Topeka and Santa Fe R. R.; some parts are also accessible from Holbrook. The region in which the petrified forests are found is the remnant of a former plain whose altitude was in the neighborhood of 5,700 feet. This plain has been deeply dissected by streams, many of whose valleys or arroyos are hundreds of feet in depth. These valleys cut the original plain into a great number of ridges, buttes, and small mesas. The mesas, which are of different elevations and vary in size from mere capstones to extensive tables, are formed by the resistance of certain sandstone layers which are here found in beds alternating with clays and shales. The sandstones are usually bluish gray or reddish brown while the clays may be white, or with bands of purple, pink or

buff, which give a pleasing effect. There also occur many beds of conglomerate and cross-bedded sandstone with numerous changes in character within short distances.

A journey of about an hour and a half by wagon or carriage from Adamana brings one to the First Forest, the portion visited by The Transcontinental Excursion of the American Geographical Society in the summer of 1912. The scenery on the way is unattractive as could be imagined; acres of level or gently-rolling land, with an occasional mesa, stretching away in the distance and reflecting the heat from the sun in a cloudless sky;

Fig. 2. Giant Trees of Prehistoric Times

several stream beds without water or with an occasional muddy pool; small bunches of sage brush or Mexican grease-wood, with here and there tufts of struggling grass which furnish scarcely enough food for the few horses, sheep and cattle seen along the way. But, on nearing the forest, interest begins to waken as the bright colored bands of the mesas appear and at some distance from the cliffs there may be seen many small, brightly colored pieces of agate or chalcedony, fore-runners as it were, of the larger blocks found between the mesas a little farther on. Here in the valleys, on the mesa slopes, on the knolls, buttes, and spurs are found the petrified logs in countless numbers.

They are found at all horizons, scattered about in the greatest confusion and consist of logs often more than 100 feet in length, of broken fragments of tree trunks or very small "chips" of all shapes and sizes which exhibit all the colors of the rainbow. One of the striking features is the great number of blocks or segments of logs, almost always broken by transverse fracture, and often presenting the general appearance of having been sawed from a log and left as they fell from the main trunk. The sections

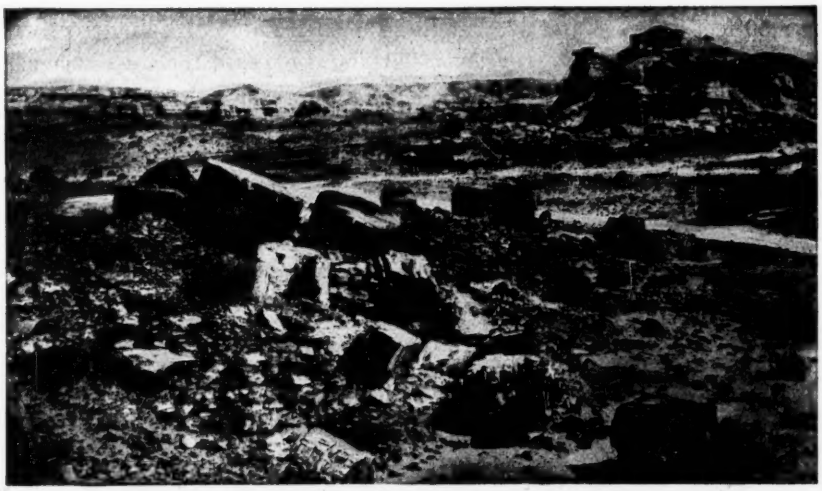


Fig. 3. A Typical Scene in the Petrified Forest

or ends of the logs present nearly every conceivable color, with a great variety of shades. Among them are yellow, red, black, white, purple and lavender; often the outside is covered with a bright red coating or "desert varnish," which on being broken exposes a light blue or lavender beneath. The bark is usually not brilliant but dull and often quite well preserved in

Fig. 4. A Giant Tree in Third Forest

form. Each piece shows some resemblance to wood, although composed of a form of quartz, as agate, chalcedony, jasper, or opal. In many cases the original structure of the wood can be seen showing plainly the cells and the rings of growth.

One of the most noticeable and attractive features is the famous natural bridge consisting of a huge petrified tree trunk spanning a ravine

over 50 feet in width and overhanging the only clump of living trees within the area covered by our excursion. This log is exposed for a distance of 111 feet and is somewhat longer, as the ends are imbedded in the rock.

Fig. 5. The Notable Petrified Bridge, First Forest

Besides being the most attractive, and most brilliantly colored of the well-known petrified forests, it is also the oldest. Those of Yellowstone National Park, of Wyoming, and of Calistoga in California are Tertiary, while the Arizona forests are early Mesozoic. The trees forming this deposit are thought to have been floated into this region before petrifaction, and imbedded in the Triassic conglomerates and sandstones which have been deeply dissected, allowing the logs and blocks to fall from higher levels to the slopes and valleys formed by erosion. It is only on the higher mesas that trees are still found *in situ*. Nowhere are trees standing upright, showing that they were removed from the place of growth. After being imbedded in the conglomerate and sandstone the vegetable matter was replaced by quartz, and it may be that some of the cracking of the logs took place then, but by far the greater portion of fractures which led to the many blocks or segments and smaller pieces are undoubtedly due to the differential heating and cooling common to arid lands.

REFERENCES: Byers, A. *Petrified Forest Covering Thousands of Acres.* Sci. Am., Vol. 92, p. 398.

Carter, O. C. S. *The Petrified Forests and Painted Desert of Arizona,* Franklin Inst. Jour., Vol. 157, pp. 293-311.

Darton, N. H. *Bulletin U. S. Geol. Survey, No.* 435.

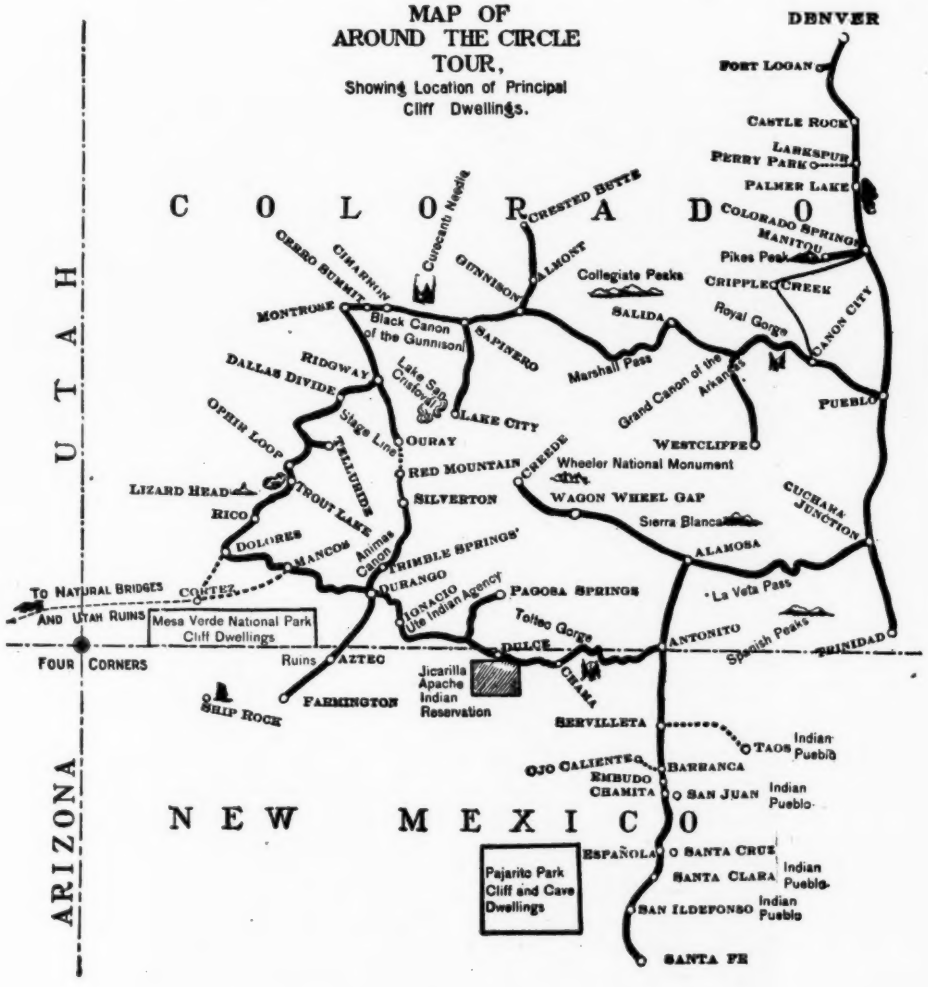
Ward, L. F. *Petrified Forests of Arizona.* Smithsonian Inst. Ann. Rept. 1899, pp. 289-307.

Map of Petrified Forest, Arizona, U. S. Geological Survey. 10 cents.

F. E. WILLIAMS

A THOUSAND MILES THROUGH COLORADO

IN grandeur of scenery, Colorado is one of our premier states. Cross Colorado as you will in any direction and by any route and the scenery is superb. Through the state, north and south, extends the continental di-



vide, whose most favorable passes are ten thousand feet in elevation and whose magnificent peaks rise nearly three miles into the air. West of Denver, Pueblo, and Colorado Springs stands the massive Front Range of the Rockies, the eastern face of the uplifted peneplain, whose softer rocks are now etched or downfolded into "parks" and valleys and through whose harder ones the rivers have carved a most wonderful series of gorges and

canyons. In season, the "parks" and valleys are green with growing crops irrigated and unirrigated. The canyons and gorges are gateways through

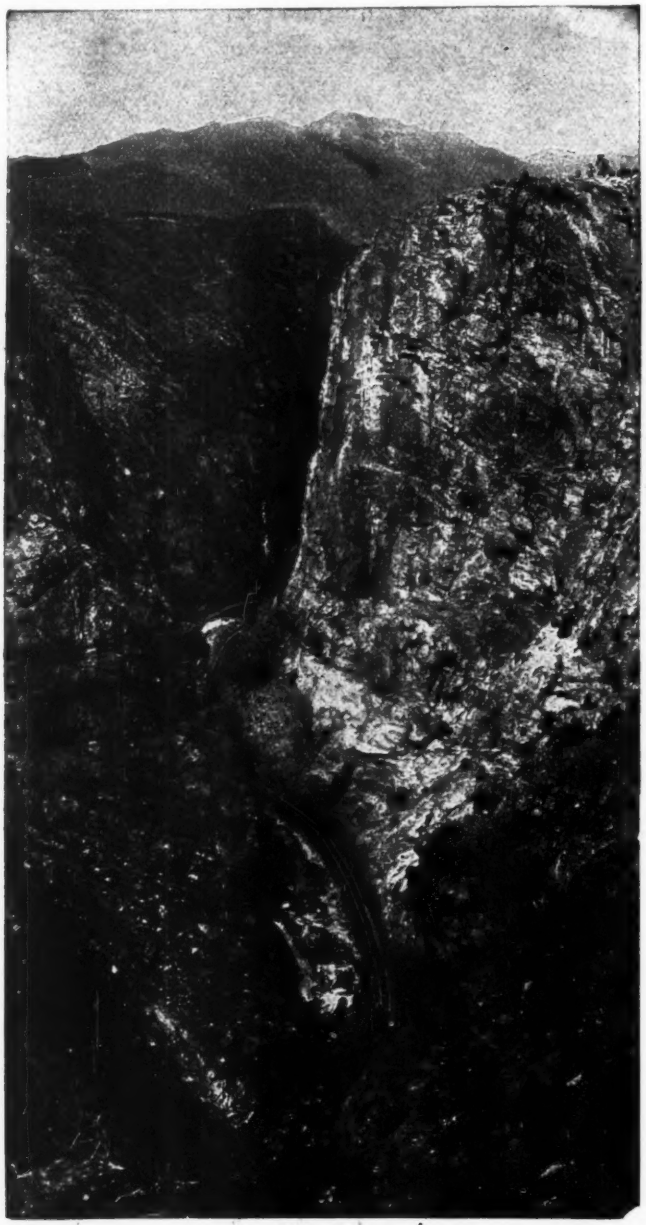


Fig. 2.

The Royal Gorge, Colo., from the Top. Tracks of the Denver & Rio Grande Railroad, 2,627 feet below.

massive barriers, in which man has laid his steel lines of communication; communication all but impossible without the river-cut gateways.

The trip here outlined is one known as the "Around the Circle Route" of the Denver and Rio Grande Railroad. Because it does make a thousand-mile circle in the most picturesque part of Colorado, it offers the tourist an opportunity of seeing in four days the most interesting part of the great Rocky Mountain mass, and of coming within easy reach of the pueblos and cliff dwellings of the southwest.

The "Around the Circle" route includes many of Colorado's most famous scenic features: Pikes Peak, Manitou and the Garden of the Gods, the Royal Gorge, the Grand Canyon of the Arkansas, Marshall Pass, the Black Canyon of the Gunnison; Ouray and the stage line, and the Canyon of the Las Animas; Ophir Loop, Lizard Head Pass and the Cliff-Dwelling ruins of the Mesa Verde; the Cumbres Divide, Toltec Gorge, the San Luis Park, La Veta Pass, etc. You may travel the entire distance by rail or you may go a small part of the way by stage coach and six.

This particular trip starts from Denver, proceeds southward along the base of the Front Range of the Rockies through Colorado Springs and Pueblo, thence west through the Royal Gorge of the Arkansas, over the Continental Divide by Marshall Pass, through the Black Canyon of the Gunnison to Montrose, as described in last month's *Journal of Geography*, (page 306).

The Royal Gorge is one of the most imposing defiles of the Rocky Mountain region. It is ten miles long, very narrow, with almost perpendicular cliffs rising 2,500 feet above the river. (Figure 2.) During the long ages since the beginning of the uplift of the ancient peneplain to form a lofty plateau, the river has been cutting this gorge through the resistant granite of the Front Range. Little wonder that such a gateway was deemed worth a fight-to-the-finish between the two railroads that sought to possess and hold it.

The crossing of the Continental Divide by way of Marshall Pass (10,856 ft.) is a notable piece of engineering. The narrow gage line makes no less than eleven loops in accomplishing the feat, with an average climb of 211 feet to the mile.

The Black Canyon of the Gunnison River is almost the equal of the Royal Gorge. These and the other canyons in this part of Colorado represent the work of rivers in the present cycle of erosion, accomplished since the uplift of the peneplain into which they are now incised. The trip southward from Montrose leads up the Uncompahgre Valley, one of Colorado's many irrigated areas. Tourists who take the stage coach route from Ouray reach an altitude of considerably over two miles at Red Mountain.

Through the wild Las Animas Canyon, the train runs along a shelf of rock, cut in the almost perpendicular face of the canyon wall; the gorge yawns on one side and the sheer face of the cliff rises on the other.

On the eastward, or return trip, the railroad crosses the Continental Divide at Cumbres (10,015 ft.) by a remarkable series of loops, follows for a distance the Toltec Gorge, skirts the edge of the Canyon of the Los Pinos and descends into San Luis Park. From Antonio a branch of the Denver and Rio Grande extends south 125 miles to Santa Fe, New Mexico, the most famous city of the old Southwest. This is the region of the cliff dwellings and pueblos. In the middle of the sixteenth century the present site of Santa Fe was occupied by an Indian pueblo of from 10,000 to 15,000 people. In 1605 the Spanish founded Santa Fe, long important as the end of the old Santa Fe trail; it is one of the most interesting of places, with its reminders of Pueblo, Spanish and Mexican days.

A typical pueblo is made of adobe or sun-dried mud, and has numerous rooms surrounding a court. The rooms rise one above another in terrace-like fashion and often are entered through a hole in the flat roof. Many families occupy one pueblo and all live in a communistic way, cultivating little pieces of land and keeping a few domestic animals.

The remainder of the return trip to Denver need not be described. It leads over more mountains, through more canyons, and by more irrigation projects and mining camps. The tourist who reaches Santa Fe should go on to the Grand Canyon of the Colorado which is described in another article in this number.*

R. H. WHITBECK.

MAMMOTH CAVE

JOURNEYING southward from Louisville on the Louisville and Nashville Railroad, an observing traveler will wonder at the infrequency —almost the absence—of streams. In a distance of 100 miles, only three are crossed; the chief one of these is Green River. But he will note the great number of saucer-like depressions or sink holes in the surface of the ground. Sometimes they are so close together as to touch one another and

*The Around the Circle ticket costs $28.00. Fuller information, and beautiful illustrative views are contained in booklets mailed free by the D. & R. G. R. R., Denver, Colorado. Some of the booklets are *Ancient Ruins of the Southwest, Ancient Cliff Dwellings of the Southwest, Around the Circle, Outdoor Life in the Rockies, Panoramic Views along the Denver and Rio Grande.*

For scientific discussion of this region, see Davis, "*The Colorado Front Range*," Annals Assn. Am. Geographers, 1:21-83, 1911, (bibliography).

several hundred of them may exist in a square mile. This is the famous cavern region of Kentucky, in the midst of which is the Mammoth Cave, situated in Edmonson County, 90 miles from Louisville.

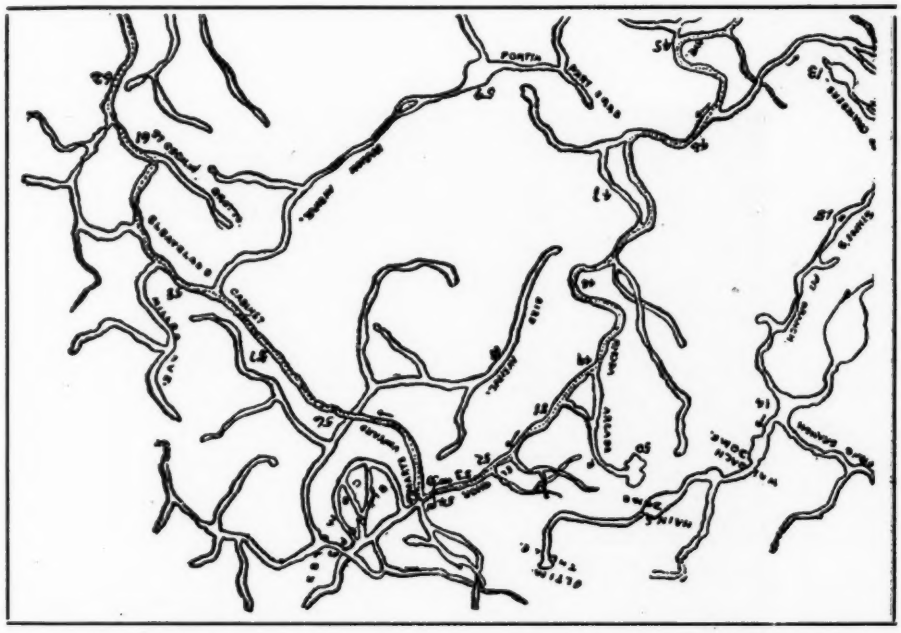


Fig. 1. Reproduction of about one-quarter of R. E. Call's map (1887) of the passages of Mammoth Cave. Even the complete map shows only a small portion of the thousands of miles of underground passages included in the caves of Kentucky.

The region is a low limestone plateau, part of which is capped by a layer of massive sandstone, 70 feet in thickness. There are as many as 500 caverns in this part of Kentucky; the the principal ones lying under the sandstone roof. Through the plateau Green River has cut a channel to a depth of some 320 feet. All of the known caverns are in the limestone, honey-combing the rock to a depth of 250 feet—that is, down to the level of Green River. It is a region of underground drainage. The limestone is soluble, and along joint planes and bedding planes, the streams have dissolved and eroded passages which they successively occupied and abandoned. "The evidence is conclusive" says State Geologist Proctor, "that these caves have been cut down to correspond with the deeping of the channel cut by Green River."*

Not simply the dissolving action of underground water, but even more, the erosive action of running water has produced the marvelous mesh of

*The Century Magazine, Vol. IV, p. 643. March, 1898.

passages in the limestone. But since here, as everywhere else, the caverns are in limestone, the most soluble of the rocks, it is evident that the solvent action of water is the initial cause of the caverns. In the lowest passage, Echo River collects the underground waters and carries them out of the cavern to join the Green River. Boats traverse Echo River for a half mile underground.

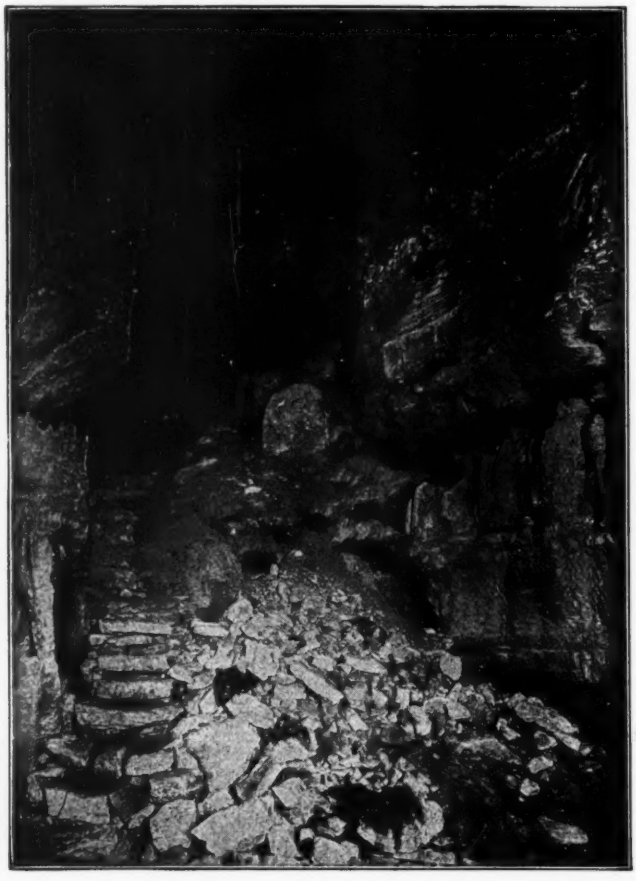


Fig. 2. Colossal Dome.

You leave the main line of the Louisville and Nashville at Glasgow Junction and take a branch line 8 or 10 miles to Mammoth Cave. Here a rambling hotel, partly built of logs, gives you accommodation and supplies you with guides at a reasonable cost.

Parties are formed, lanterns and a guide are provided, and you start on some one of the half dozen different scheduled trips through the cave. At the entrance to the cavern, you pause, if it is summer. The cave tempera-

ture is 54° and out of the sloping passage leading into the cave a strong current of cool air shoots with considerable force like water from a nozzel. By walking directly toward the cavern mouth, the cool "breath of the cave" strikes you first in the face. then as you advance nearer the entrance your whole body is bathed in the cool air and your body temperature is reduced so that you may enter the cavern without danger of chilling. The temperature is practically invariable at 54° F. throughout the year. In summer, the cave breathes *out* and in winter, it breathes *in*.

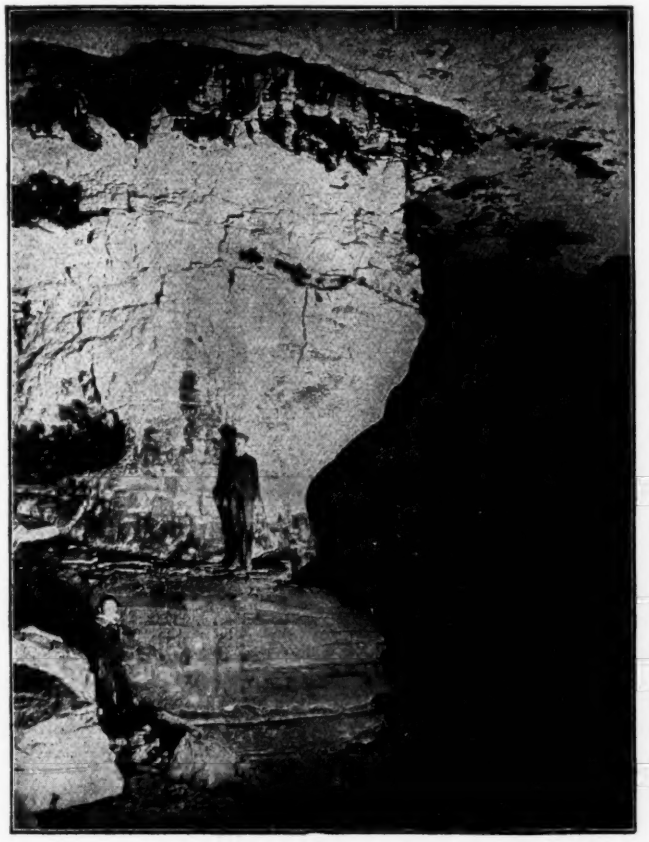


Fig. 3. The Acute Angle

In the miles of passages, an endless variety exists. By the weak light of the lanterns you see but imperfectly. Seeing is the lesser sensation by which the cave impresses itself upon you. You *feel* the place more than you see it:—you feel the silence; it settles down upon you. When the lanterns are put out and you sit in absolute quiet, in absolute darkness, in the Star Chamber, a mantle of mystery and gloom enwraps you that is indescribable. But the droll remarks of the guide keep you cheerful.

The passages wind in and out, up and down, divide and subdivide, widen into the Mammoth Dome, 150 feet or more high, drop to the "bottomless" pits, 100 feet deep, narrow into the Corkscrew or the Fat Man's Misery; open into Gothic Avenue with its monster stalactites already made, or into Olive's Bower where they may be seen in the making; they carry you to the great chamber where thousands of visitors, each adding a stone to a pile representing his college, or lodge, or fraternity or state, have built up a city of cairns; conduct you to Echo River, whose arched roof and tunnel

Fig. 4. Gypsum Formations

give a hundred echoes for every sound, and whose waters are the home of the fish which have eyes but see not; or they lead you to the Star Chamber in whose vaulted roof the crystals gleam like stars when the guide turns the light upon them.

In most places the cave is perfectly dry. The air is remarkably dry. Wooden vats and troughs used in preparing saltpetre for gun-powder in the war of 1812, are still undecayed.

In the main cavern, stalactites and stalagmites are few, but in less frequented caverns they are more common, though nowhere as numerous as visitors expect.

No one knows even vaguely how many miles of underground passages exist in this part of the state, but they aggregate many thousands. Fig. 1 shows a portion of the area that has been mapped, but this is a small fraction of the whole.

The distance from Chicago to the Mammoth Cave is about 460 miles, from Cincinnati about 200 miles, and from St. Louis about 350 miles.

Rates at the hotel are $2.00 a day. The guide's fees for the short trip is $2.00 and for the long trip $3.00.

REFERENCES: Hovey, *Celebrated American Caverns.* Hovey and Call, *Illustrated Manual of Mammoth Cave.*

Hovey, *Mammoth Cave; Its Environs and Contents,* in *Jour. of Sch. Geog.* 1:133, May, 1897.

Mammoth Cave, a Booklet of Information sent free by the Louisville and Nashville R. R., Louisville, Ky. R. H. WHITBECK.

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Geography of South America, Assistant Professor Tower.

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Geography in the Grammar Grades, Miss Collins (First Term), Associate Professor Baber. (Second Term).

Theory of Teaching Elementary School Geography, Associate Professor Baber.

Geography in the High School, Associate Professor Baber.

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Meteorology and Climatology, Laboratory Course, Mr. Mordoff.

Geography of North America, Assistant Professor von Engeln.

Aims and Methods in Geography, Associate Professor Whitbeck.

DENISON UNIVERSITY, GRANVILLE, OHIO

Special Teachers' Course in Geography, Professor W. M. Gregory.

Elementary Geology, Professor Gregory.

Commercial Geography, Professor Gregory.

HARVARD UNIVERSITY, CAMBRIDGE, MASS.

Field Geology, Field Work in the Rocky Mountains, Mr. Haynes.

Structural or Glacial Field Work, Montana the probable field, Associate Professor Jay B. Woodworth.

INDIANA UNIVERSITY, BLOOMINGTON, IND.

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Conservation of Natural Resources, Professor Cumings.

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Field work in the Yellowstone and Glacier National Parks, July 28 to August 16, Mr. Lehnerts.

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Field Course, Study of an area in Colorado or Wyoming, making a typographic map of same, and mapping areal geology, Mr. Branson.

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RAY HUGHES WHITBECK, *Editor*

LAWRENCE MARTIN, *Associate Editor*

Of the Department of Geology and Geography of the University of Wisconsin

CONTENTS FOR JUNE

		Page
Foreword		309
The Grand Canyon of the Colorado	*W. M. DAVIS*	310
The Yellowstone National Park	*N. M. FENNEMAN*	314
The Grand Coulee of Washington	*R. E. DODGE*	320
Mount Mazama and Crater Lake	*LAWRENCE MARTIN*	322
Glacier National Park	*LAWRENCE MARTIN*	324
The Yosemite National Park, extracts from U. S. Geol. Survey Booklet by	*F. E. MATTHES*	326
The Petrified Forests of Arizona	*F. E. WILLIAMS*	329
A Thousand Miles Through Colorado	*R. H. WHITBECK*	333
Mammoth Cave	*R. H. WHITBECK*	336
University Summer School Courses in Geography	*F. E. WILLIAMS*	341

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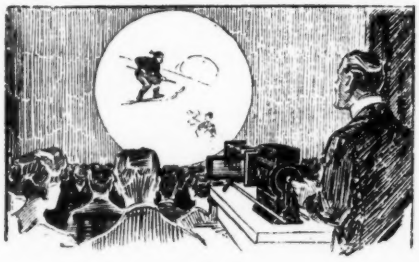

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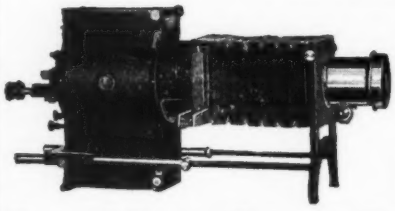

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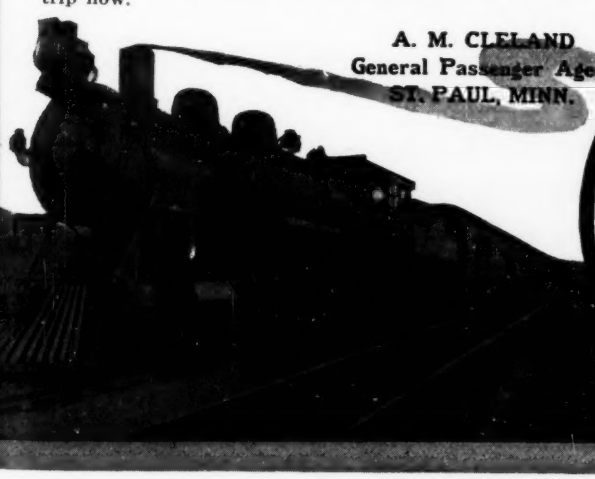

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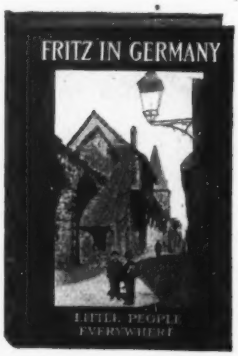

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